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Variables in Turbine Erosion

Continual development of new, high strength alloys has resulted in progressively increased efficiency in the operation of turbomachinery. As a result, turbines with tip speeds in excess of 2000 ft/sec are now being used in many applications in the power industry, such as in large steam generating systems, and are contemplated for liquid metal-vapor systems.

Erosion, resulting from impact between the rapidly moving blade and slowly accelerated condensate droplets, has been periodically "solved" by utilizing better materials or liquid extraction and related methods, but the phenomenon has never been fully understood nor has it been possible to predict the results for any particular design.

A comprehensive test program was undertaken to investigate the effects of turbine stator blade shape, rotor blade shape, and variation in test conditions. Simultaneously, an analytical program was developed and correlations with predicted results were made. The purpose of this program was to identify the non-dimensional parameters governing the origin and propagation of damaging droplets.

Tests were designed to explore the nondimensional groups that govern the thermo-, hydro-, and aerodynamics of the turbine erosion process using steam as the working fluid, which permits visualization by unique applications of high-speed photography. The formation of moisture and its motion along the blades and casings were investigated and the results provided information which considerably advanced the state of the art in the field of impact erosion. In addition, problem areas to be avoided and improved practices to be followed were established. The compilation of this selected, verified information should enable the engineer to predict the possibility of damage caused by erosive action in future configurations, permitting

better long-lived machines to be designed and operated.

The second phase of this program to investigate variables in turbine erosion resulted in test data which have been correlated with other analyses. Considerable background in understanding the origin and nature of the droplet formation has also been obtained using numerous high-speed photographic films. In addition, data acquisition techniques have been advanced for this type of program.

Within the limitations imposed by the use of only one test fluid, the equation proposed by Pouchot

$$(We)_{crit} = \frac{K}{S_b^{2/3}} \left(\frac{\mu_D}{\mu_v} \right) \left(\frac{\rho U}{\sigma} \right)^{7/6} \left(\frac{L}{a} \right)^{1/6}$$

can be used to predict droplet size in the turbine. Droplet generation from the liquid film collected on the turbine blades can be correlated with areas of secondary flow and separation. A turbine in which characteristics of the wake are minimized showed less erosive damage.

Notes:

1. Further research is planned to correlate test data with mathematical data. The test turbine available as part of this program could be used to study flow problems such as the influence of secondary flow, wakes, and separation, and to define shapes by which adverse geometric effects can be avoided. The study of the existence of supersaturation and the location of the reversion point will be continued.
2. Data acquisition techniques developed and used were very promising. The possibility of using holography to record data over the volume behind the stator is being considered.

(continued overleaf)

3. Because fluid-property influence remains undetermined with tests conducted with only one fluid (water), tests may be planned with other fluids, such as n-hexane which appears to have suitable properties.

4. Requests for further information may be directed to:

Technology Utilization Officer
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No patent action is contemplated by NASA.

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